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ASSESSMENT OF GROUNDWATER QUALITY IN AND AROUND BIDADI INDUSTRIAL AREA, RAMANAGAR DISTRICT, KARNATAKA

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ABSTRACT

The water quality index (WQI) is a single number that expresses the quality of water by integrating the water quality variables. The purpose is to provide a simple and concise method for expressing the water quality for different usage. The present work deals with the monitoring of variation of seasonal ground water quality index of ground water for Bidadi industrial area in Bangalore, Karnataka state of India. For calculating the WQI the following 13 physic-chemical parameters such as pH, Electric Conductivity, Total Dissolved Solids, Total Alkalinity, Chlorides, Total Hardness, Dissolved Oxygen, Fluoride, Iron, Calcium, Magnesium, Sulphate and Nitrate have been considered. The water quality index value of ground water was 113.9. In the present investigation the quality of water was found to be poor in and around Bidadi industrial area.

KEYWORDS: Ground Water, Physico-Chemical Parameters, Water Quality Index, Water Quality Standards

INTRODUCTION

The fresh water is of vital concern for mankind since it is directly linked to human welfare. Ground water is an important natural source of water supply all over the world. Its use in irrigation, industrial and domestic usage continues to increase where perennial surface water source are absent. The modern civilization, over exploitation, rapid industrialization and increased population has lead to fast degradation of our environment. The quality of ground water may depend on geology of particular area and also vary with depth of water table and seasonal changes and is governed by the extent and composition of the dissolved salts depending upon source of the salt and soil-surface environment.

Water quality index provides a single number that expresses overall water quality at a certain location and time, based on several water quality parameters. The objective of water quality index is to turn complex water quality data into information that is understandable and usable for common man. A single number is not enough to describe the water quality: there are many other water quality parameters that are not included in the index. However, a water quality index based on some very important parameters can provide a simple indicator of water quality. In general, water quality indices incorporate data from multiple water quality parameters into a mathematical equation that rates the health of a water body with number (Yogendra et al., 2007).

OBJECTIVE OF PRESENT WORK

The objective of the present research is to provide information on the physico-chemical characteristics of ground water in order to discuss it's suitability for human consumption based on computed water quality index values.

PARAMETERS OF WATER QUALITY ANALYSED

For the assessment of water pollution status of the groundwater, the following water quality parameters were analyzed: (1) pH, (2) Electric Conductivity, (3) Total Dissolved Solids, (4) Total Alkalinity, (5) Chlorides, (6) Total Hardness, (7) Dissolved Oxygen, (8) Fluoride, (9) Calcium, (10) Iron (11) Magnesium, (12) Sulphate and (13) Nitrate.

STUDY AREA

For the present study Bidadi Industrial Area was selected. Bidadi Industrial Area is 2km away from SH-17. It is located at $N12^{0}47'$and $E77^{0}23'$ and in the north-eastern part of the Ramanagara Taluk, Ramanagara District. A number of villages surrounding the Industrial Area are Anchipura, Abbanakuppe, Bannigere, Maregowdana Doddi, Byramangala, Shanamangala, Parasanapalya, Thimmegowdana Doddi and Vrishbavathipura. Industrial area covers 852 acres. Ramanagara Taluk covers 62,930 hectares of geographical area and consists of 4 Hoblies namely Bidadi, Kasaba, Kailancha and Kootgal. The taluk had 126 villages, 23 Gram Panchayats and Municipal Council. According to the 2011 census, total population is approximately 3.5lakhs.Detailed survey was conducted to identify the number of existing bore wells. The survey was conducted by visiting each industrial plot and surrounding the industries by identifying the existing of bore wells and open wells.

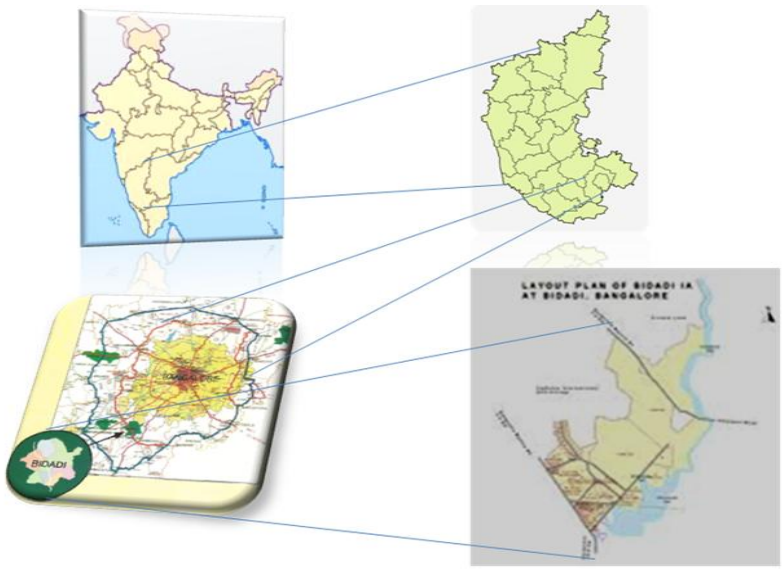


Figure 1: Key Map of the Study Area

MATERIALS AND METHODS

The water samples from nine open wells and three bore wells were collected and analysed for 13 physico-chemical parameters by following the established procedures. The parameters pH, electrical conductivity and dissolved oxygen were monitored at the sampling site and other parameters were analysed in the laboratory as per the standard procedure of APHA (1995)

The WQI has been calculated by using the standards of drinking water quality recommended by the World Health Organisation (WHO), Bureau of Indian Standards (BIS) and Indian Council for Medical Research (ICMR). The calculation of WQI was made using a weighted arithmetic index method given below (Brown et al., 1972) in the following steps.

Calculation of Sub Index of Quality Rating (q_n)

Let there be *n* water quality parameters where the quality rating or sub index (q_n) corresponding to the n^{th} parameter is a number reflecting the relative value of this parameter in the polluted water with respect to its standard permissible value. The value of q_n is calculated using the following expression

$$q_n = 100[(V_n-V_{io})/(S_n-V_{io})] \quad (1)$$

Where,

q_n = Quality rating for the n^{th} water quality parameter.

V_n = Observed value of the n^{th} parameter.

S_n = Standard permissible value of n^{th} parameter.

V_{io} = Ideal value of n^{th} parameter in pure water.

All the ideal values (V_{io}) are taken as zero for drinking water except for pH=7.0, Dissolved Oxygen = 14.6 mg/L, and Fluoride = 1 mg/L.

Calculation of Quality Rating for pH

For pH the ideal value is 7.0 (for natural water) and a permissible value is 8.5 (for polluted water). Therefore, the quality rating for pH is calculated from the following relation:

q_{pH} = $100[(V_{pH}-7.0)/(8.5-7.0)]$

Where,

V_{pH} = observed value of pH during the study period.

Calculation of Quality Rating for Dissolved Oxygen

The ideal value (V_{io}) for dissolved oxygen is 14.6 mg/L and standard permitted value for drinking water is 5mg/L. Therefore, quality rating is calculated from following relation:

q_{DO} = $100[(V_{DO} - 14.6)/(5 - 14.6)]$

Where,

V_{DO} = observed value of dissolved oxygen

Calculation of Quality Rating for Fluoride

The ideal value (V_{io}) for fluoride is 1 mg/L and standard permitted value for drinking water is 1.5 mg/L. Therefore, quality rating is calculated from following relation:

Q_F = $100[(V_F - 1)/(1.5 - 1)]$

Where,

V_F = observed value of fluoride.

Calculation of Unit Weight (W_n)

Calculation of unit weight (W_n) for various water quality parameters are inversely proportional to the recommended standards for the corresponding parameters.

$$Wn = K/S_n$$

Where,

W_n = unit weight of n^{th} parameters

S_n = standard value for n^{th} parameters

K = constant for proportionality and is given as (Kalavathy et al., 2011):

$$K=1/[1/V_{S1}+1/V_{S2}+\ldots\ldots\ldots+1/V_{sn}]$$

Calculation of WQI

WQI is calculated from the following equation

$$WQI = \sum_{i=1}^{n} q_n W_n / \sum_{i=1}^{n} W_n$$

Table 1 shows the classification of water quality status based on Water Quality index (Ramakrishnaiah et al. 2009, Bhaven et al. 2011 and Srinivasa Kushtagi et. al. 2012,).

Table 1: Water Quality Classification Based on WQI Value

Class	WQI Value	Water Quality Status
I	<50	Excellent
II	50-100	Good Water
III	100-200	Poor water
IV	200-300	Very poor water
V	>300	Water unsuitable for drinking

Table 2: Drinking Water Standards, Recommending Agencies and Unit

SL NO	Parameters	Permissible Value (Sn)	Recommended Agency	1/Sn	Unit Weight
1	PH	8.5	ICMR/BIS	8.5	0.028
2	Ec (µ-s/cm)	300	ICMR	300	0.0007
3	TDS (mg/Lt)	500	ICMR/BIS	500	0.0004
4	Total Alkalinity (mg/ Lt)	200	ICMR	200	0.001
5	Chlorides (mg/Lt)	250	ICMR	250	0.0009
6	Total Hardness (mg/Lt)	300	ICMR/BIS	300	0.0007
7	Ca (mg/Lt)	75	ICMR/BIS	75	0.003
8	Mg (mg/Lt)	30	ICMR/BIS	30	0.007
9	Fluorides (mg/Lt)	1.5	BIS	1.5	0.16
10	Sulphate (mg/Lt)	200	ICMR/BIS	200	0.001
11	Iron (mg/Lt)	0.3	BIS	0.3	0.79
12	Sodium (mg/Lt)	200	BIS	200	0.001
13	Nitrate (mg/Lt)	45	ICMR/BIS	45	0.005

RESULTS OF WATER QUALITY ANALYSED

The individual data acquired for each element are shown in Table 3. The statistical analysis results are summarized as minimum, average, median and standard deviation of pH, Electric Conductivity (EC), Total Dissolved Solids (TDS), Chlorides (Cl), Total Hardness, Calcium (Ca), Magnesium (Mg), Fluorides (F), Sulphates (SO_4), Iron (Fe), Sodium (Na), Nitrate (NO_3) (Table 4).

Table 3: Physico-Chemical Characteristics of Ground Water (Mg/L)

Sl. no	pH	EC (µ-s/cm)	TDS	TH	Ca	Na	SO_4	TA	Cl	Fe	F	NO_3	Mg
1	7.18	1179	765.6	412	48	117.4	68.74	426	174.55	0.319	0.7	3.022	70.95
2	7.29	814.1	521	304	70.4	57.2	35.59	300	122.39	0.838	0.369	1.663	30.104
3	7.21	1166	746.2	476	48	97.1	34.79	230	168.53	0.194	0.52	3.066	86.508
4	7.47	1562	999.7	492	46.4	143.7	111.46	468	224.71	0.635	1.391	3.856	91.368
5	7.19	1434	917.8	620	33.6	85.2	156.19	410	198.63	0.194	0.459	2.452	130.24
6	7.16	1436	919	460	36.8	137.1	73.73	386	238.76	1.88	0.79	5.78	89.424
7	7.19	1319	844.2	564	20.8	83.7	28.41	456	218.69	0.55	0.527	1.575	124.416
8	7.49	1231	807	504	46.4	80.9	40.589	452	200.64	0.29	0.189	0.216	94.284
9	7.44	1202	769.3	448	25.6	101.6	35.997	446	194.62	0.55	0.64	2.277	93.912
10	7.62	956.5	612.2	392	81.6	59.7	40.39	372	128.4	NIL	0.369	0.26	45.684
11	7.27	1239	793	396	86.4	126.5	66.346	420	178.56	NIL	0.767	4.338	43.74
12	7.28	995.8	637.3	288	81.6	102.9	63.351	396	104.33	NIL	0.542	1.04	20.412
13	7.35	834.1	533.8	356	75.2	53.5	31	236	128.4	NIL	0.212	4.07	40.824
14	7.36	694.7	444.6	292	65.6	50.3	14.03	358	60.19	NIL	0.242	0.128	31.104
15	7.31	652.6	417.7	252	65.6	49.7	20.224	258	82.624	NIL	0.34	4.645	21.384

Table 4: Summary of Concentration in Ground Water (Mg/L)

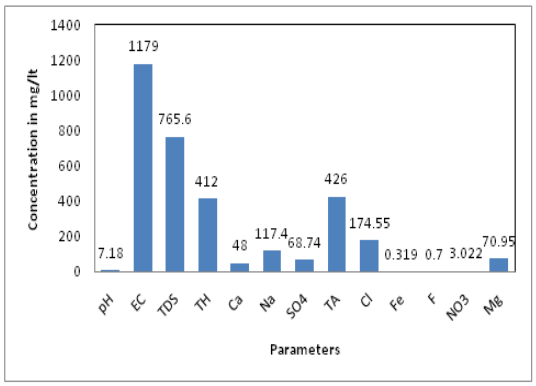
Statistical Parameters	pH	EC (µ-s/cm)	TDS	TH	Ca	Na	SO_4	TA	Cl	Fe	F	NO_3	Mg
Maximum	7.62	1562	999.68	620	86.4	143.7	156.2	468	238.76	1.88	1.39	5.78	130.24
Minimum	7.16	652.6	417.66	252	20.8	49.7	14.03	230	60.19	0.19	0.19	0.13	20.412
Average	7.32	1114.4	715.22	417.06	55.47	89.77	54.72	374.3	161.6	0.61	0.54	2.56	67.623
Median	7.29	11.79	765.56	412	48	85.2	40.39	396	174.55	0.55	0.52	2.45	70.95
Std. dev	0.14	278.85	179.3	106.7	21.28	31.86	37.71	81.3	54.27	0.53	0.31	1.76	36.68
Std. Value	8.5	300	500	300	75	200	200	200	250	0.3	1.5	45	30

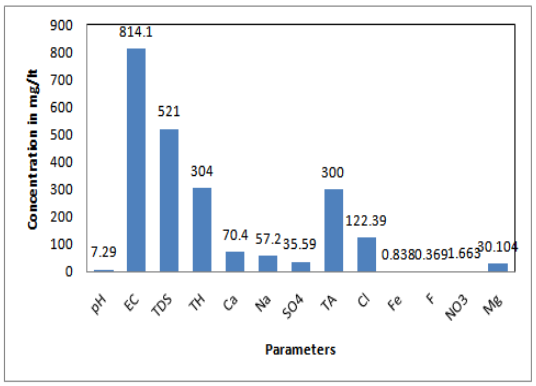
Table 5: Calculations of Water Quality Index

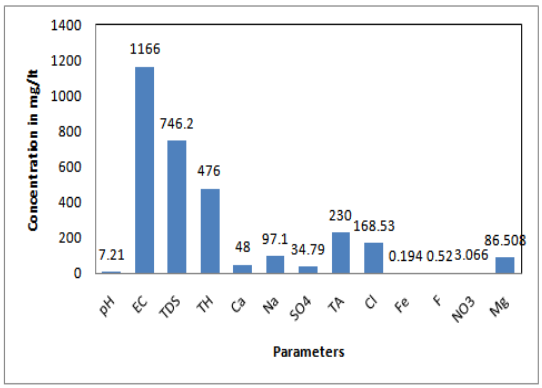
Sl No	Parameters	Standard Per-Missible Value (Sn)	1/Sn	Unit Weight (Wn)	Observed Value	Quality Rating (Qn)	Weighted (Wnqn)
1	pH	8.5	8.5	0.028	7.32	21.33	0.6
2	EC	300	300	0.0007	116.4	372.2	0.26
3	TDS	500	500	0.0004	714.5	142.9	0.06
4	Total Alkalinity	200	200	0.001	401	200.5	0.2
5	Chlorides	250	250	0.0009	161.6	64.7	0.06
6	Total Hardness	300	300	0.0007	417.1	139.1	0.097
7	Ca	75	75	0.003	55.5	74	0.22

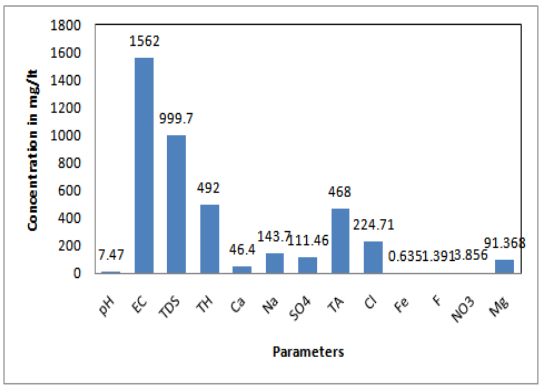
Table 5: Contd.,

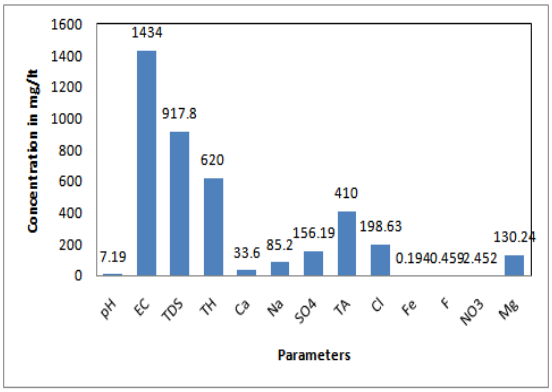
8	Mg	30	30	0.007	67.7	225.7	1.6
9	Fluorides	1.5	1.5	0.16	0.54	-92	14.72
10	Sulphate	200	200	0.001	54.7	27.35	0.03
11	Iron	0.3	0.3	0.79	0.36	120	94.8
12	Sodium	200	200	0.001	89.8	44.9	0.05
13	Nitrate	45	45	0.005	2.56	5.7	0.03
		TOTAL	**4.213**	**0.99**			**112.8**
Water Quality Index=113.9							

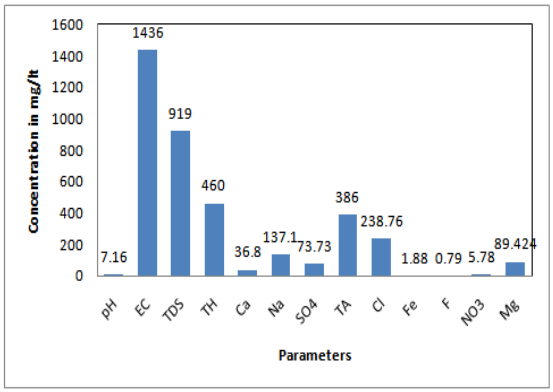


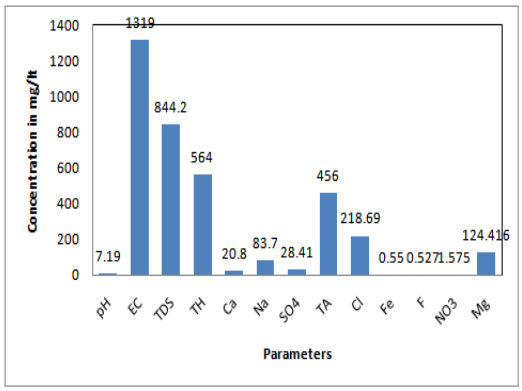








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456
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0.527
1.575
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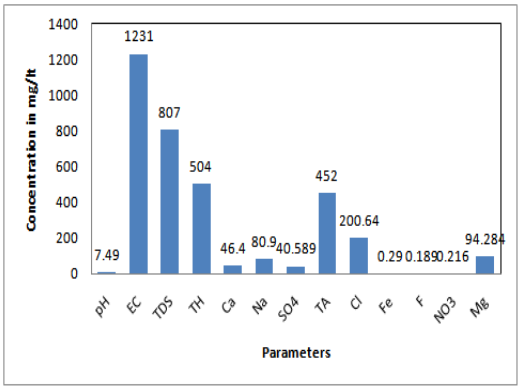
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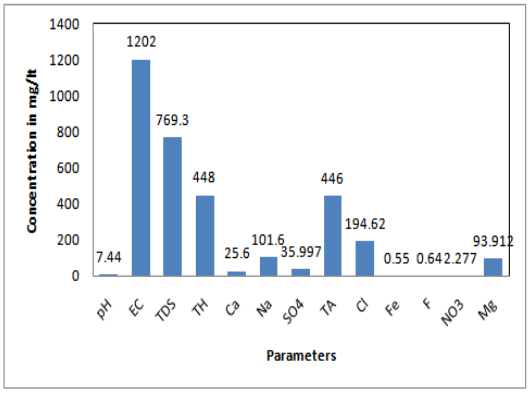
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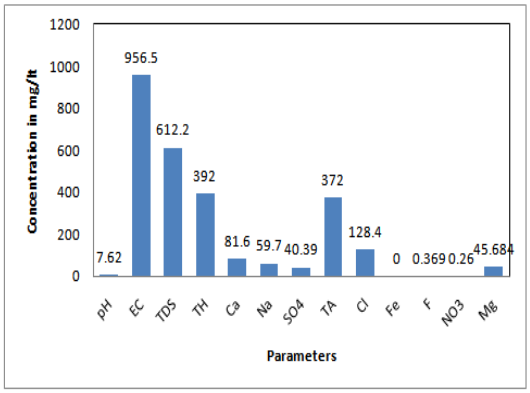
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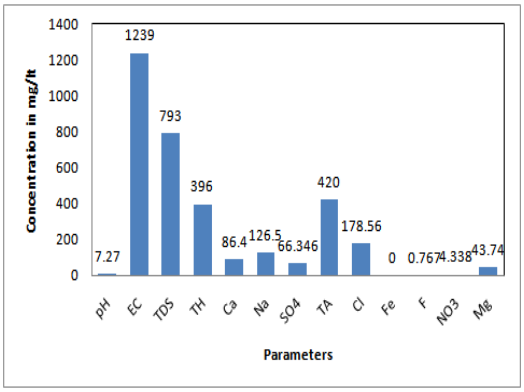
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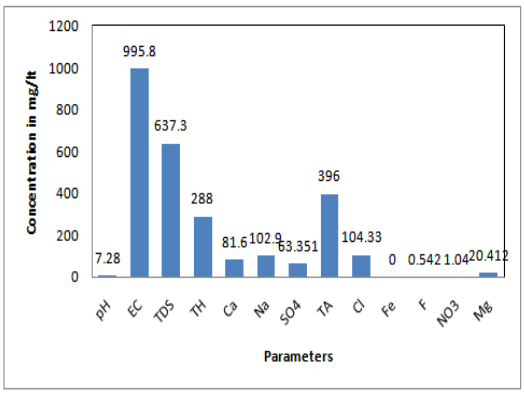
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81.6
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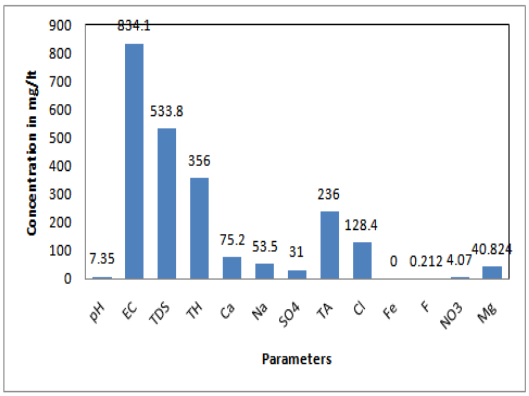
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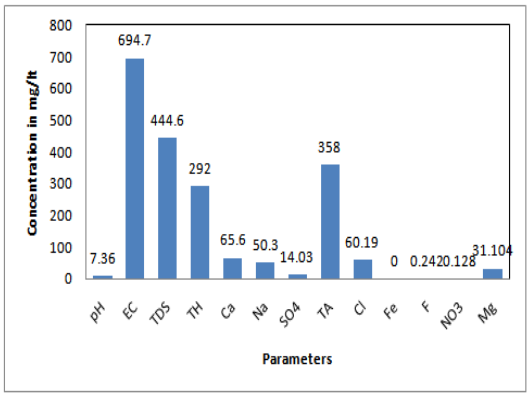
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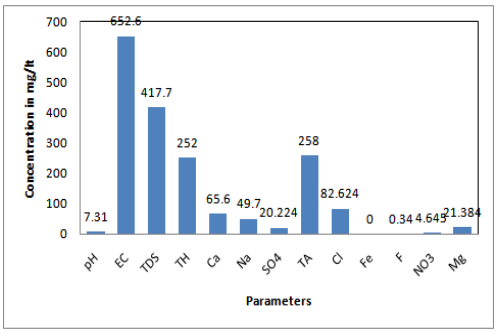

Figure 2: Graphical Representation of Water Quality Parameters at Different Sampling Locations

RESULTS AND DISCUSSIONS

Water quality index computed for study area is tabulated in Table 5. The computed WQI for the study area was found to be 113.9. The high value of WQI is because of high concentration of Electric Conductivity, Total Dissolved Solids, Total Hardness, Total Alkalinity, Iron and Magnesium. The physic-chemical parameter analytical results were also used for calculating WQI for different sampling blocks. By the calculated WQI value the water is poor in quality.

CONCLUSIONS

Application of WQI in this study has been found using in assessing the overall quality of water. It is helpful for public to understand the quality of water as well as being a useful tool in many ways in the field of water quality management. Analysis of ground water samples from 15 sampling points in the surrounding area of Industrial Area showed the significant spatial variation of the parameters analysed (pH, TDS, Total Hardness, Ca, Na, SO_4, Alkalinity, Cl, Fe, F, NO_3, and Mg & EC). The analysis shows that the value of Total Hardness, Fe, Mg, Ca, Total alkalinity, Total Dissolved Solids exceeds the permissible limits. The study reveals the overall WQI values computed in **pre monsoon** season under Class III of Table 1, indicates that the water quality is poor but it is suitable for drinking and other domestic purposes after certain degree of treatments.

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